and also shortened.

Each of independent claims 1 and 15 has been rejected under 35 USC 102(e) as being anticipated by U.S. patent 6,201,329 to Chen. The Examiner states, referring to FIG. 1 of Chen, that Chen teaches an apparatus comprising a rotor 34 and a stator 36 and an electrically energizable coil 92 and 94 for modulating magnetic flux between the stator and rotor magnets. The Examiner refers to FIGS. 7 and 8 of Chen for a teaching of first and second axially spaced combinations each including at least one permanent magnet 204 and 206 disposed on each of the rotor and stator and polarized to levitate the rotor.

With respect to claim 1, the Examiner refers to FIGS. 4 and 5 of Chen for electrical circuitry 110 for regulating electrical energy to the coils for stabilizing the rotor axially. The Examiner refers to col. 16, lines 32 to 45 (which is claim 5 of Chen) for the rotor magnets being offset axially of the stator magnets respectively such that the rotor magnets are offset axially inwardly of the corresponding stator magnets or such that the rotor magnets are offset axially outwardly of the corresponding stator magnets. Such an offset is discussed at col. 15, lines 5 to 11, of Chen, which is with reference to FIG. 10 of Chen.

With respect to claim 15, the Examiner refers to FIGS. 4 and 5 for a first electrical circuit for regulating electrical energy to the coils for maintaining a reference position of the rotor and a second electrical circuit responsive to feed-back of electrical energy to at least one of the coils for modifying the reference position 110.

Independent method claim 20 has been rejected on the basis that the method of bearing a rotor would be inherent and obvious, the Examiner stating that the prior art references meet the structural limitations of the claimed device.

The remaining claims have been rejected under Chen, either by itself or in combination with U.S. patent 5,928,131 to Prem. Prem was cited for disclosing a comparator and an integrator for the second circuit, elements which are not recited in any of the independent claims 1, 15, and 20. Therefore, it is believed to be unnecessary to discuss Prem relative to independent claims 1, 15, and 20.

Independent claims 1, 15, and 20 have been amended to more clearly recite what Applicant regards as the invention. As amended, each of claims 1, 15, and 20 recites that each combination includes at least one permanent magnet disposed on each of said rotor and said stator on opposite sides of a respective axially extending gap portion. Support therefor may be found in the first full paragraph on page 7 of the specification and in FIGS. 1 and 3 of the drawings, the portions of the gap 30 on opposite sides of which the respective permanent magnets are disposed being clearly shown to be axially extending. For the reasons provided hereinafter, it is respectively submitted that each of the claims, as amended, is not anticipated by and is unobvious over the references of record.

The present invention is directed to a magnet assembly for bearing a rotor both radially and axially, i.e., to act as both radial and thrust bearings, and, in accordance with an object of the present invention, to provide such an assembly which is simplified, compact, and reliable. The rotor loads (both radial and thrust) are borne by a pair of axially spaced combinations, each combination including at least one permanent magnet on each of the stator and the rotor on opposite sides of a respective axially extending gap portion and polarized to levitate the rotor. Magnet flux between the respective stator and rotor magnets is modulated by an electrically energizable coil. Electric energy to the coils is regulated to stabilize the rotor

axially.

In order to achieve acceptable angular and axial stability, in accordance with a feature of the present invention, the rotor magnets are offset axially from the stator magnets such that the rotor magnets are each offset axially inwardly from the corresponding stator magnet or such that the rotor magnets are each offset axially outwardly from the corresponding stator magnet. The resulting opposition in axial forces allows a zero force balance to be attainable, and the circuitry for attaining a zero force balance is described in the next paragraph. The current direction and magnitude in the coils will vary their magnetic flux which in turn, due to interaction of the coil magnetic flux with the magnetic flux between the stator and rotor magnets, will vary the axial forces to achieve stability of the zero force balance position of the rotor. See the second full paragraph on page 7 of the specification.

In order to attain a zero force balance position of the rotor wherein the current to the coils may be reduced to near zero so as to achieve low power consumption for such a magnet assembly, in accordance with a feature of the present invention, a first electrical circuit is provided for regulating electrical energy to the coils for maintaining a reference position of the rotor, and a second electrical circuit is responsive to feed-back of electrical energy to at least one of the coils for modifying the reference position. See the specification from page 9, fifth line from bottom, to page 12, line 5.

The use of the same magnets for bearing both axial and radial loads in accordance with the present invention advantageously allows greater compactness of the pump to be achieved, and the magnetic flux between the rotor and stator magnets may be modulated by use of the coil to achieve good radial and angular stiffness to support the rotor while

maintaining axial stability. Moreover, the axial position reference is continuously re-set based on electrical energy feed-back to achieve zero force balance, whereby a minimum of current (energy) may be used to stabilize the bearing thereby to prevent blood damage due to heat (when the apparatus is used as a blood pump) as well as to provide more economical operation. In addition, the combined axial and radial bearings of the present invention allows a streamlined flow path through the apparatus, when used as a blood pump, which is desirable for preventing blood damage.

The Chen patent is assigned to the assignee of the present application and is discussed in the paragraph which spans pages 1 and 2 of the specification. Chen discloses in a first embodiment a blood pump wherein passive permanent magnet rings are provided in attraction on opposite sides of each of two axially spaced radial gaps to levitate the rotor, and an actively controlled (i.e., energized by electrical coil means) magnetic means is provided across radial gaps to bear thrust. In a second embodiment, Chen discloses a blood pump having a pair of combinations of passive magnets on a rotor and a stator across axially extending gap portions and a thrust bearing utilizing an actively controlled magnet means, the rotor magnets being of necessity offset from the stator magnets at some times as the rotor is moved axially. In a fourth embodiment, Chen discloses a blood pump having a combination of passive axially offset magnets on a rotor and a stator across an axially extending gap portion. This fourth embodiment also discloses a combination of magnets on the rotor and stator across a radially extending gap, which latter combination is part of a thrust bearing assembly.

It should be noted, referring to the Brief Description of the Drawings at col. 3, lines 9 to 41, that Chen discloses several embodiments, i.e., a first embodiment in FIGS. 1 to 6,

11, and 12; a second embodiment in FIGS. 7 and 8; a third embodiment in FIG. 9; and a fourth embodiment in FIG. 10. When combining elements from one embodiment with elements from another embodiment, even though in the same reference, in order to show anticipation, as was done in the rejection, it is not sufficient to merely show that each element is found in the reference. <u>The elements must be arranged as required by the claim</u>. See the discussion at section 2131 of the MPEP.

For the rejection of each of claims 1 and 15, the Examiner pointed to some elements in the first embodiment and some other elements in the second embodiment and, for claim 1, some other elements in the fourth embodiment. In the first embodiment, the Examiner pointed to an electrically energizable coil (92 and 94 in FIG. 1) for modulating magnetic flux between respective stator and rotor magnets and electrical circuitry (110) for regulating electrical energy to the coils for stabilizing the rotor axially.

Also in the first embodiment, the Examiner points, with respect to claim 15, as amended, to a first electrical circuit for regulating electrical energy to the coils for maintaining a reference position of the rotor and a second electrical circuit responsive to feed-back of electrical energy to at least one of the coils for modifying the reference position (110, FIGS. 4 and 5).

Unlike the present invention as claimed in claims 1 and 15, as amended, the first embodiment of Chen discloses a pair of sets 74 and 76 of magnets for levitation and a separate magnet ring 88 energized by coil 92 and 94. The magnets 74 and 76 are not energized by any coils, i.e., they are described at col. 5, line 25, as being passive, meaning that they are not connected to an electrical source for control of magnetic flux (col. 5, lines 29 to 31). Only the magnet ring 88, which is on the rotor, is associated with the coil 92 and 94. Thus, contrary to the

Examiner's assertion, the coil 92 and 94 does not modulate magnetic flux between respective stator and rotor magnets.

Moreover, contrary to the present invention as claimed in claims 1 and 15, as amended, the magnets of each set 74 and 76 of permanent magnets, which include magnets 80 and 84 disposed on the stator and magnets 78 and 82 disposed on the rotor (FIG. 2), are disposed on opposite sides of a respective radially extending gap portion. They are thus not disposed on opposite sides of a respective axially extending gap portion, as required by each of claims 1 and 15, as amended.

Thus, the first embodiment does not disclose or suggest the arrangement of elements as required by either of claims 1 and 15, as amended.

In the second embodiment (FIGS. 7 and 8), the Examiner points, with respect to each of claims 1 and 15, as amended, to first and second axially spaced combinations of rotor and stator magnets for levitating the rotor.

The second embodiment does not disclose or suggest a coil for modulating flux between the magnets. Instead, this second embodiment teaches a separate thrust bearing 230 having a coil and magnets.

Thus, the second embodiment also does not disclose or suggest the arrangement of elements as required by either of claims 1 and 15, as amended.

In the fourth embodiment (FIG. 10), the Examiner points, with respect to claim 1, as amended, to the magnets facing each other across an axial gap being axially offset.

The fourth embodiment, like the other embodiments, does not disclose or suggest a coil for modulating flux between the offset magnets.

Thus, the fourth embodiment, like the other embodiments, does not disclose or suggest the arrangement of elements as

required by either of claims 1 and 15, as amended.

Each of the embodiments of Chen is complete in and of itself and therefore does not require elements from the other. There is no impetus or motivation in Chen for combining the first, second, and fourth embodiments. Thus, Chen does not disclose the arrangement of elements as required by either of claims 1 and 15, as amended, as well as claim 20, as amended.

Moreover, even if two or more of the embodiments of Chen were combined, it would still not result in the present invention. Inter alia, such a combination would not teach or suggest an electrically energizable coil modulating magnetic flux between respective stator and rotor magnets which face each other across an axially extending gap portion, as provided by the present invention.

Neither Chen or any other of the art of record, whether taken together or individually, discloses, teaches, or suggests apparatus wherein first and second axially spaced combinations each includes at least one permanent magnet disposed on each of a rotor and a stator on opposite sides of a respective axially extending gap portion and polarized to levitate the rotor and an electrically energizable coil for modulating magnetic flux between the respective stator and rotor magnets, electrical circuitry for regulating electrical energy to the coils for stabilizing said rotor axially, and wherein the rotor magnets are offset axially of the stator magnets respectively such that the rotor magnets are offset axially inwardly of the corresponding stator magnets or such that the rotor magnets are offset axially outwardly of the corresponding stator magnets, as claimed in claim 1, as amended, so as to allow a zero force balance to be attainable in order to provide a simplified, compact, and reliable magnet assembly which allows a streamlined pump flow path to be achieved and which bears a rotor both radially and

axially, i.e., to act as both radial and thrust bearings. Therefore, it is respectfully submitted that claim 1, as amended, is novel and unobvious over the prior art and is therefore patentable.

Neither Chen or any other of the art of record, whether taken together or individually, discloses, teaches, or suggests apparatus wherein first and second axially spaced combinations each includes at least one permanent magnet disposed on each of a rotor and a stator on opposite sides of a respective axially extending gap portion and polarized to levitate the rotor and an electrically energizable coil for modulating magnetic flux between the respective stator and rotor magnets, a first electrical circuit for regulating electrical energy to the coils for maintaining a reference position of the rotor, and a second electrical circuit responsive to feed-back of electrical energy to at least one of the coils for modifying the reference position, as claimed in claim 15, as amended, in order to provide a simplified, compact, and reliable magnet assembly which allows a streamlined pump flow path to be achieved and which bears a rotor both radially and axially, i.e., to act as both radial and thrust bearings, and to attain a zero force balance position of the rotor wherein the current to the coils may be reduced to near zero so as to achieve low power consumption for such a magnet assembly. Therefore, it is respectfully submitted that claim 15, as amended, is novel and unobvious over the prior art and is therefore patentable.

Neither Chen or any other of the art of record, whether taken together or individually, discloses, teaches, or suggests a method for bearing a rotor wherein first and second axially spaced combinations each including at least one permanent magnet disposed on each of the rotor and a stator are provided on opposite sides of a respective axially extending gap portion and

polarized to levitate the rotor, an electrically energizable coil is provided for each of the combinations, electrical energy to the coils is regulated for maintaining a reference position of the rotor, and the reference position is modified in response to feed-back of electrical energy to at least one of the coils, as claimed in claim 20, as amended, in order to bear a rotor both radially and axially with a simplified (which allows a streamlined flow path to be achieved), compact, and reliable magnet assembly, i.e., wherein the same magnet assembly acts as both radial and thrust bearings, and to attain a zero force balance position of the rotor wherein the current to the coils may be reduced to near zero so as to achieve low power consumption for such a magnet assembly. Therefore, it is respectfully submitted that claim 20, as amended, is novel and unobvious over the prior art and is therefore patentable.

Since the remaining claims, as amended, are dependent on one or the other of claims 1, 15, 20, as amended, it is respectfully submitted that they are also patentable for at least the same reasons respectively.

Since each of the claims, as amended, has been shown to be patentable, it is respectfully submitted that this application is in condition for allowance, and such is respectfully requested. If it would aid in advancing this application to issue, the Examiner is respectfully urged to call the undersigned attorney for Applicant at the number below.

Respectfully submitted,

James C. Simmons

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Enclosures

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Version with Markings to Show Changes Made

In the Abstract:

The Abstract (on page 18 of the specification) has been amended as follows:

A magnetic bearing wherein ~~comprising~~ axially spaced combinations of permanent magnets on a rotor and stator ~~which~~ are polarized to levitate the rotor and positioned with the rotor magnets offset axially outwardly (or inwardly) of the stator magnets ~~(or the rotor magnets offset axially inwardly of the stator magnets)~~ to allow a force balance to be achievable to bear axial thrust. An electrically energizable coil modulates magnetic flux between the respective stator and rotor magnets for each combination. A first electrical circuit ~~is provided to regulate~~ regulates electrical energy to the coils for maintaining a reference position of the rotor. A second electrical circuit compares ~~responsive to~~ feed-back of electrical energy to at least one of the coils ~~is provided for comparing thereof~~ with a reference electrical energy of about zero amps or volts and ~~integrating~~ integrates the differences ~~therebetween~~ until the difference is about zero to provide a signal to modify the reference position, whereby to attain a zero force balance position wherein the current which must be supplied to the coils may be reduced to near zero.

In the Claims:

Claim 1 has been amended as follows:

Claim 1 (amended). Apparatus comprising a rotor, a stator, first and second axially spaced combinations each including at least one permanent magnet disposed on each of said rotor and said stator on opposite sides of a respective axially extending gap portion and polarized to levitate said rotor and further

including an electrically energizable coil for modulating magnetic flux between said respective stator and rotor magnets, electrical circuitry for regulating electrical energy to said coils for stabilizing said rotor axially, and said rotor magnets being offset axially of said stator magnets respectively such that said rotor magnets are offset axially inwardly of said corresponding stator magnets or such that said rotor magnets are offset axially outwardly of said corresponding stator magnets.

Claim 15 has been amended as follows:

Claim 15 (amended). Apparatus comprising a rotor, a stator, first and second axially spaced combinations each including at least one permanent magnet disposed on each of said rotor and said stator <u>on opposite sides of a respective axially extending gap portion</u> and polarized to levitate said rotor and further including an electrically energizable coil for modulating magnetic flux between said respective stator and rotor magnets, a first electrical circuit for regulating electrical energy to said coils for maintaining a reference position of said rotor, and a second electrical circuit responsive to feed-back of electrical energy to at least one of said coils for modifying said reference position.

Claim 20 has been amended as follows:

Claim 20 (amended). A method for bearing a rotor comprising providing first and second axially spaced combinations each including at least one permanent magnet disposed on each of the rotor and a stator <u>on opposite sides of a respective axially extending gap portion</u> and polarized to levitate the rotor, providing an electrically energizable coil for each of the combinations, regulating electrical energy to the coils for maintaining a reference position of the rotor, and modifying, in

response to feed-back of electrical energy to at least one of the coils, the reference position.